Claims

1.

Apparatus for inspecting lean of a container having a container bottom, which includes:

means for holding a container in position and rotating the container around an axis,

a light source positioned beneath the container in said means for directing light energy onto the bottom of the container,

a light sensor positioned beneath the container to receive portions of the light energy from said source reflected from the container bottom, and

an information processor coupled to said light sensor for determining, as a combined function of said reflected light energy and container rotation, departure of the container bottom from a plane perpendicular to said axis.

2.

The apparatus set forth in claim 1 wherein said light energy is directed from said source onto a periphery of the container bottom.

3.

The apparatus set forth in claim 2 wherein the container includes knurling around the container bottom, and said image process or is responsive to said reflected light energy to determine depth of said knurling.

4.

The apparatus set forth in claim 1 wherein said information processor includes a preprocessor for scanning said light sensor at first increments of container rotation, and a main processor for receiving scan data from said preprocessor at second increments of container rotation greater than said first increments.

5.

The apparatus set forth in claim 1 wherein said means for holding the container in position and rotating the container around an axis includes spaced backup rollers for externally engaging the container, and a drive roller for engaging and rotating the container while holding the container against said backup rollers so as to define an average axis of rotation as a function of geometry of the container and spacing between said backup rollers.

6.

The apparatus set forth in claim 1 comprising two of said light sources and two of said light sensors positioned in pairs on diametrically opposed sides of said axis, said information processor being responsive to compression of outputs of said light sensors to indicate lean of a container.

7.

An optical inspection apparatus for inspecting the bearing surface of a container, comprising:

a light source positioned generally beneath the bearing surface and being capable of emitting light that strikes the bearing surface,

a light sensor positioned generally beneath the bearing surface and being capable of receiving light reflected from the bearing surface and providing a sensor output signal representative of the reflected light, and

an information processor for receiving said sensor output signal and utilizing said signal to determine the departure of the bearing surface from a plane that is perpendicular to an axis of the container.

8.

The optical inspection apparatus of claim 7, wherein said light source is positioned to emit incident light that strikes the bearing surface of the container at an acute angle, with respect to the axis of the container.

9.

The optical inspection apparatus of claim 8, wherein said light sensor is positioned to receive light reflected from the bearing surface at an acute angle, with respect to the axis of the container.

10.

The optical inspection apparatus of claim 7, wherein said apparatus further includes an additional light source and an additional light sensor, said light source and light sensor are part of a first probe and said additional light source and light sensor are part of a second probe.

11.

The optical inspection apparatus of claim 10, wherein said first probe inspects a first point of the bearing surface and said second probe inspects a second point of the bearing surface.

12.

The optical inspection apparatus of claim 11, wherein said first and second points are located at opposite ends of a diameter of the bearing surface.

13.

The optical inspection apparatus of claim 7, wherein the container is rotated while said light source emits incident light, thus causing said incident light to strike different segments of the bearing surface, and said information processor scans said light sensor at increments of container rotation.

14.

The optical inspection apparatus of claim 7, wherein said light source comprises a laser diode and a line generator for emitting an incident line-shaped light beam.

15.

The optical inspection apparatus of claim 7, wherein said light sensor comprises an array sensor having a plurality of pixels, each of said pixels being capable of generating a numerical value representative of the light intensity at said pixel.

16.

The optical inspection apparatus of claim 7, wherein said apparatus further includes a lens system positioned generally between the bearing surface and said light sensor.

17.

The optical inspection apparatus of claim 16, wherein said lens system comprises a cylindrical lens and a spherical lens having a focal point, said light sensor being positioned near said spherical lens focal point.

18.

The optical inspection apparatus of claim 7, wherein said apparatus is adapted for inspecting a bearing surface having a plurality of knurls.

19.

The optical inspection apparatus of claim 18, wherein inspection of a knurled bearing surface causes said light sensor to receive non-continuous reflections from a knurl peak and a knurl valley.

20.

The optical inspection apparatus of claim 19, wherein said sensor output signal at least includes first outputs representing reflections from the knurl peak and second outputs representing reflections from the knurl valley.

21.

The optical inspection apparatus of claim 20, wherein said electronic processor is adapted to utilize said first outputs to determine container lean.

22.

The optical inspection apparatus of claim 20, wherein said electronic processor is adapted to utilize both said first and second outputs to determine knurl depth.

23.

The optical inspection apparatus of claim 7, wherein said information processor includes a pre-processor electronically coupled between said light sensor and said electronic processor, said pre-processor being adapted to compress data from said sensor output signal.

24.

The optical inspection apparatus of claim 23, wherein said light sensor scans the reflected light at a first interval and said pre-processor scans the output of said light sensor at a second interval, said second interval being greater than said first interval.

25.

The optical inspection apparatus of claim 7, wherein said information processor is adapted to generate a sinusoidal expression representative of the height differential between two positions on the bearing surface.

26.

The optical inspection apparatus of claim 25, wherein said information processor uses a least square fitting technique to derive values for one or more variables of said sinusoidal expression.

27.

The optical inspection apparatus of claim 26, wherein said derived values can be used to determine container lean.

28.

The optical inspection apparatus of claim 26, wherein said information processor also uses an iterative search method for determining a sine cycle for said sinusoidal expression.

29.

The optical inspection apparatus of claim 28, wherein said iterative search method is a golden section search.

30.

The optical inspection apparatus of claim 26, wherein said information processor also uses a selection process involving Min/Max data points to improve the efficiency of the least square fitting technique.

31.

An inspection station for rotating and inspecting the bearing surface of a container, said station comprising a slide plate, a drive roller, and the optical inspection apparatus of claim 7.

32.

An indexing and inspection machine for inspecting containers, said machine comprising an inspection station that includes the optical inspection apparatus of claim 7.

33.

A method of inspecting a container bearing surface, comprising the steps of:

(a) providing a light source generally facing the bearing surface,

(b) providing a light sensor generally facing the bearing surface,

(c) rotating the container about an axis,

(d) causing said light source to emit light which reflects off of a position on the bearing surface,

(e) causing said light sensor to record the position at which the reflected light strikes said light sensor, and

(f) analyzing the bearing surface from said position data.

34.

The method of claim 33, wherein step (f) further includes analyzing the lean of the container from said position data.

35.

The method of claim 33, wherein the bearing surface being inspected is a knurled surface.

36.

The method of claim 33, wherein step (e) further includes compressing data from said recorded position data.

37.

The method of claim 33, wherein step (f) further includes utilizing a sinusoidal expression to model the bearing surface of the container.

38.

The method of claim 37, wherein one or more variables of said sinusoidal expression are solved using a least square fitting technique.

39.

A method of reducing the amount of data processed during optical inspection of a container bearing surface, comprising the steps of:

(a) providing an optical inspection apparatus having a light source, a light sensor, a pre-processor, and a primary processor;

(b) causing said light source to reflect light off of the bearing surface;

(c) causing said light sensor to record the position of the reflected light at a first interval,

(d) causing said pre-processor to scan said recorded position data of step (c) at a second interval, said second interval being greater than said first interval,

(e) causing said primary processor to analyze the bearing surface from said scanned data of step (d).

40. A method of analyzing the bearing surface of a container during optical inspection, comprising the steps of:

(a) providing a first optical probe for illuminating a first point on the bearing surface;

(b) providing a second optical probe for illuminating a second point on the bearing surface;

(c) causing said first and second optical probes to reflect light off of the bearing surface and record data pertinent to said reflections;

(d) utilizing a sinusoidal expression representative of the relative positions of the first and second points, said expression having at least one variable;

(e) utilizing a least square fitting technique to solve for said at least one variable; and

(f) utilizing said at least one variable to analyze the bearing surface.